NASA Innovative Advanced Concepts

Space Debris Elimination (SpaDE)

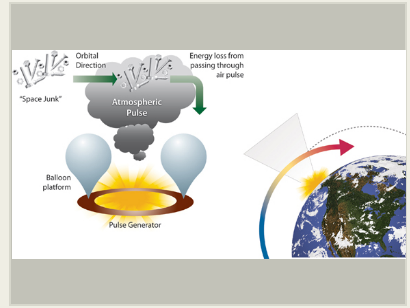
Completed Technology Project (2011 - 2015)

Project Introduction

The amount of debris in low Earth orbit (LEO) has increased rapidly over the last twenty years. This prevalence of debris increases the likelihood of cascading collisions that cause the debris generation rate to outstrip the rate at which debris deorbits, falling into the atmosphere and burning up. This accumulation creates debris belts that render many orbits unusable. Current strategies emphasize debris mitigation, as there is no practical method for debris removal. Raytheon BBN Technologies (BBN) and the University of Michigan will study the Space Debris Elimination (SpaDE) system to remove debris from orbit by firing focused pulses of atmospheric gases into the path of targeted debris. These pulses will increase drag sufficiently to cause the deorbit rate to exceed the debris generation rate. The pulses themselves will fall back into the atmosphere, leaving no residual trace in orbit to interfere with LEO satellites. In contrast to other proposed methods, SpaDE is failsafe, in that it places no solid material in orbit where a malfunction could create new debris. This project will conduct technology risk reduction analyses and modeling. The research will produce an academic paper and presentation describing the technical results and providing the foundation for future work, to include prototyping, field experiments and ultimately deployment of a SpaDE system.

Anticipated Benefits

SpaDE represents an unusual concept of operations in that it would be capable of addressing the problem of debris too small to be tracked by ground-based radar and yet large enough to damage or destroy space craft. SpaDE also would have the capability to address debris fields, acting to clear a volume of space without the possibility of the fratricidal generation of debris belts.



Project Image Space Debris Elimination (SpaDE)

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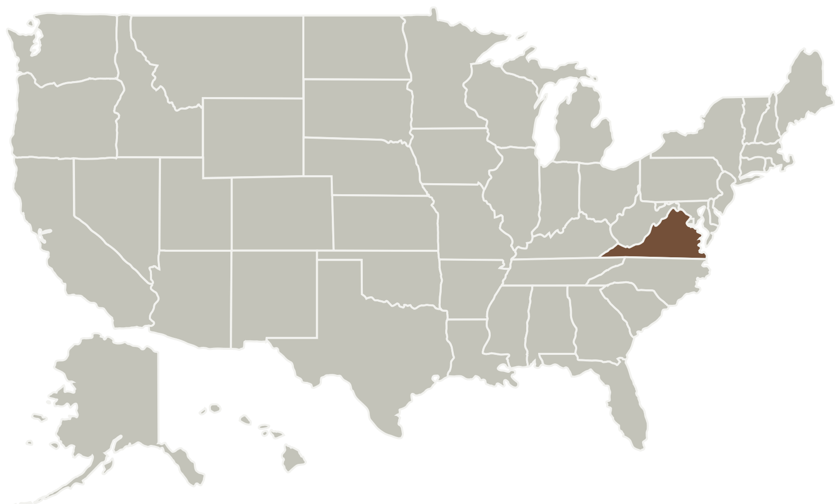
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Raytheon Company	Lead Organization	Industry	
University of Michigan-Ann Arbor	Supporting Organization	Academia	Ann Arbor, Michigan

Primary U.S. Work Locations
Virginia

Project Transitions

September 2011: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Raytheon Company

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

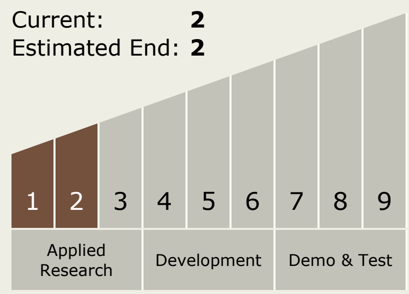
Eric A Eberly

Principal Investigator:

Daniel Gregory

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



February 2015: Closed out

Closeout Summary: In summary, SpaDE phase I has shown: 1. Perturbations at altitudes of approximately 80km can reach orbital debris at 600km 2. Expansi on of the gas cloud propagates in the horizontal directions while keeping a comp act vertical profile creating a disk 3. There is a leading shock wave the proceeds the pressure wave 4. Vertical velocity is required to move the mass to altitude 5. The sheer winds at 150km did not significantly affect the perturbation SpaDE phase I showed that a compressed mass of atmosphere would stay coherent for altitudes up to 600km. The model shows that the gas dynamics allow for the per turbation to reach altitude with sufficient density to affect debris. Higher altitude s should be possible but were not tested in this study. Being able to heat and ac celerate a large mass of atmosphere at 80km would take a large amount of ener gy. The targeting aspect of space debris is reduced because of the large surface area that SpaDE is capable of producing. This surface area allows for lax timing i n firing the perturbation and for compensating for the error of uncertainty in the debris position. These advantages are ideal for smaller debris (<10cm) targeting as well as fields of debris (i.e. multiple debris in close orbital proximity). SpaDE could be used for clearing a debris field after a satellite collision. There is a leadi ng shock wave that precedes the main propagation of mass. This shock wave co uld be used to steer debris around hazards or potentially changing the apogee a nd perigee of the debris. Changing the apogee and perigee of the debris could b e used for hazard avoidance or it could be used to deorbit the debris sooner. Stu dies need to be done to determine the vertical component required to affect deb ris. The initial vertical velocity of the perturbation follows ballistic trajectory. The GITM model is highly dependent on gravity and the effects of particles in the up per atmosphere that are affected by the gravitation force of the earth. SpaDE de monstrates that there is a relationship between the initial velocity and height of the perturbation. The SpaDE concept appears to be a viable concept that could h elp eliminating debris in the lower parts of LEO. Although the energy requiremen ts are high, they are not impractical. More work should be done to make the sys tem more efficient and effective. To advance SpaDE to TRL 3, we need to deter mine if the energy requirements can be reduced. Other modalities may help low er the energy requirements of the system and may provide additional performan ce benefits. Vortex rings, laminar flow, and simultaneous gravity waves appear t o be promising modalities. Another area for future study would be to estimate th e effects of the shock wave that propagates ahead of the main pressure wave. T his shock wave could be used to change the trajectory of the debris without cha nging the debris velocity. For objects in near circular orbits, this would have the effect of increasing their perigees and lowering their apogees. Lowering apogee will increase drag because the object is moving faster through denser air for tha t part of its orbit. However, such action could have side effects, the most import ant being that the new ephemeris could interfere with operational satellites. Ano ther possible side effect of the SpaDE concept is that debris could skip off the pe rturbation. This could deorbit the debris faster, but it might create risks to opera tional satellites. And finally, we would like to determine the extent to which we c ould control the effects of the perturbation; for example, whether it would be po ssible to consistently place debris over the Pacific Ocean during their final desce nt into atmosphere.

Technology Areas

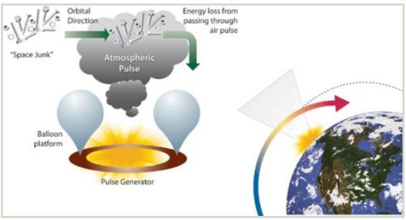
Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - └ TX05.6 Networking and Ground Based Orbital Debris Tracking and Management
    - └ TX05.6.3 Orbital Debris Mitigation

Target Destination

Earth

Images



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Project Image Space Debris Elimination (SpaDE)
(https://techport.nasa.gov/image/102291)